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TITLE: ② Dependence of the noise figure of a communications system on its design parameters

PERIODICAL: ③ Izvestiya vysshikh uchebnykh zavedeniy, Radiotekhnika, v. 5, no. 6, 1962, 699 - 706

TEXT: A communications system (see Fig. 1) consisting of active elements T_i (converters, amplifiers) and passive elements Π_i (transmission lines and paths, interstage networks, filter networks, etc.) is considered. The transfer function of the system is γ and its overall insertion loss due to the passive elements is:

$$G = \prod_{i=1}^{m+1} g_i$$

where g_i is the power-insertion loss introduced by a passive element Π_i and m is the number of elements; $K_i \geq 1$ is the Card 1/4

S/142/62/005/006/005/011
E192/E382

Dependence of the noise figure

power-amplification of the i -th active element. Under the assumption that the noise introduced by each passive element is σ_{Π}^2 and that of each active element referred to its input is σ_T^2 , the noise power at the output of the system can be written as:

$$P_{out} = (P_{in} + \sigma_T^2) \frac{K_1 K_2 \dots K_m}{g_1 g_2 \dots g_{m+1}} + (\sigma_{\Pi}^2 + \sigma_T^2) \left| \frac{K_1 K_2 \dots K_m}{g_1 g_2 \dots g_{m+1}} + \frac{K_2 K_3 \dots K_m}{g_2 g_3 \dots g_{m+1}} + \dots + \frac{K_m}{g_{m+1}} \right| + \sigma_{\Pi}^2 \quad (4)$$

where P_{in} is the noise power at the input of the system. It is seen from Eq. (4) that for $K_i = 1$ (where $i = 1, 2, \dots, m$) the noise figure due to the design parameters is a minimum. The system of Fig. 1a can be simply represented by that of Fig. 1b under these conditions. The expression for the output noise is differentiated with respect to K_i and m and it is found that

Card 2/4

S/142/62/005/006/005/011
E192/E382

Dependence of the noise figure

the minimum noise figure can be expressed as:

$$N_{\min} = 1 + \frac{1}{P_a} \left[e \frac{(\sigma_N^2 + \sigma_T^2)}{K_{o \max}} \ln \left(\frac{G\gamma}{K_{o \max}} \right) + \frac{\sigma_N^2}{\gamma} + \sigma_T^2 \right] \quad (12)$$

where $K_{o \max} = P_{\Delta} / (P_a + \sigma_T^2)$, where P_{Δ} is the permissible output power. For the case when $P_a = P_{\Delta}$, $K_{o \max} = 1$ and $\gamma = 1$, it is found that the minimum noise figure is achieved when the transmission system is divided into equal sections in which the insertion loss of the passive elements and the gain of the active elements are equal to $e = 2.71$; the number of active plus passive pairs is $m = \ln G$. The noise figure for $\gamma = 1$ and $K_{o \max} = 1$ for any m is given by:

$$N_{\left(\begin{smallmatrix} P_a = P_{\Delta} \\ \gamma = 1 \end{smallmatrix} \right)} = 1 + \frac{1}{P_a} (\sigma_N^2 + \sigma_T^2) m G^{1/m} \quad (15)$$

Card 3/4

S/142/62/005/006/005/011

Dependence of the noise figure ... E192/E382

This expression permits evaluation of the deviation of the noise figure from the optimum value. There are 6 figures.

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